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Effect of Gum Arabic in Management of Malnourished Children Aged 6 – 59 Months

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Abstract
Background: Malnutrition is globally the most important risk factor for morbidity and mortality, contributing to more than half of deaths in children worldwide. Gum Arabic is indigestible food ingredient with a potential effect as prebiotic and antidiarrheal. Aim of the study: To determine the effect of gum Arabic in management of malnourished children aged 6- 59 months and its effect on edema, diarrhea, and mood changes among them. Method: This is an interventional, open-label randomized, controlled trial, hospital-based study conducted among 162 malnourished child admitted to Ahmed Gasim Teaching Hospital and Mohammed Elamin Hamid Pediatric Hospital during Jan. – July 2015. Participants were selected randomly, and equally distributed to control group (81 malnourished children) who were managed as guided by the WHO developed protocol for managing malnutrition and study group (81 malnourished children) received gum Arabic in addition to management protocol and the both groups received management for 2 weeks (30 mg/day for children > 1 year and 15 mg/day for children < 1 year). Results: Out of 162 malnourished children, 54.3% had age of 13- 24 months, males were 64.2%. On starting, 72.8% had weight for height <-3SD, 46.3% of them had diarrhea, 35.2% had edema, 65.4 were irritable and 24.1% were apathetic. On 14th day, in study and control groups, mean WFH increased by 9.26% and 7.6% respectively, diarrhea stopped in 97.06% and 78.05% respectively, edema subsided in 96.7% and 57.1% respectively, Also, 98.6% from study group and 73.2% from control group were active and smiling. The variation in the 4 assessed variables was revealed statistically significant (P value < 0.05). Conclusion and recommendation: Gum Arabic found to have positive effect when added to the WHO management protocol for severe acute malnutrition. Wide and well-established use of gum Arabic as Prebiotic will increase its economic values.
Keywords: Gum Arabic, Malnourished, Children

1. Introduction

Malnutrition is globally the most important risk factor for illness and death, contributing to more than half of deaths in children worldwide; child malnutrition was associated with 54% of deaths among children in the developing countries in 2001.-Protein-energy malnutrition (PEM), first described in the 1920s, is observed most frequently in the developing countries, but has been described with an increasing frequency in the hospitalized and chronically ill children in the United States.

Gum Arabic was evaluated for acceptable daily intake for man by the Joint FAO/WHO Expert Committee on Food Additives since 1969[4,5]; however, Sudanese people in Western Sudan has been using it for long time without limitations. It is indigestible to both humans and animals, not degraded in the intestine, but fermented in the colon to give short-chain fatty acids, leading to a large range of possible health benefits[6]. One of these benefits is the prebiotic effect[7,8]. It has been claimed that four weeks' supplementation with Gum Arabic (10 g/day) led to a significant increase in Bifidobacteria, Lactobacteria, and Bacteriodes indicating a prebiotic effect [8].

Ready-to-use Therapeutic Foods (RUTF) are high-energy, lipid-based spreads are used in any cultural setting for the treatment of severe acute malnutrition (SAM). They are designed to be used in Phase 2 for the rehabilitation of severely malnourished populations and to provide the same nutritional profile as F100 therapeutic milk. RUTF may be the sole source of food, except water and/or breast milk, during the period of use. RUTF must meet the specifications of the United Nations Children's Emergency Fund (UNICEF) Supply Catalog for therapeutic spreads (http://www.supply.unicef.dk/ catalogue). RUTF spreads are packaged in 92-gram sachets, and subsequently in cases of 150 sachets. They have a shelf life of two years when they are stored at 80 degrees Fahrenheit, and are designed to be used in any climactic setting. For a full product, specifications refer to the USDA Commodity Requirements Document and/or the Commercial Item Description for Ready-to-Use Therapeutic Foods[9].

2. **Aim of the study:** To determine the effect of gum Arabic in management of malnourished children aged 6-59 months and its effect on edema, diarrhea, and mood changes among them.

3. **Research hypothesis**: Gum Arabic will be effective for improving weight gain & mood changes, and for reducing severity of edema and diarrhea episode.

4. Methodology

4.1. Research design: an interventional, open-label randomized control trial, hospital-based study.

4.2. Setting: Ahmed Gasim Pediatric Hospital & Mohammed Alamin Hamed (Omdurman) Pediatric Hospital.
Ahmed Gasim Hospital is one of the major general pediatric hospitals in Sudan, it is located in Bahri City, Khartoum State. It receives different referred cases from Khartoum State and other states of Sudan. It contains outpatients (emergency and cold cases) PICU, malnutrition ward and general pediatric wards. The outpatients receive average of 150 patients / day.
Mohammed Alamin Hamed Pediatric Hospital – is located in Omdurman City, South East of Omdurman. It is a teaching Hospital that mainly serves Omdurman residents, in addition to cases referred from Khartoum State and other Sudan states. It contains nursery, PICU, renal unit, malnutrition ward, and general pediatric wards. The outpatients receive average of 300 patients/ day.

4.3. Sample: the total coverage method was used for determining a sample size by choosing admission to the malnutrition ward in each hospital during the period of the study (6 months). The patients were divided into two groups in simple random way, so the total number was even 162 malnourished children. Each group include 81 patients. On 1st day, the children are randomly recorded in the group (study or control)
Inclusion criteria:
- Malnourished children age 6 month < 5years.

Exclusion criteria:
- Children with other co-morbidities (e.g. congenital heart disease).
- Refusal of participation in the study.

4.4. Tool of data collection:
The data was collected by using predesigned questionnaire. One tool was used in this study which included
Part I: bio demographic data which included gender, age, weight and height and WHO child growth standard as weight for height
Part II: sings of acute malnutrition which included presence of diarrhea, number of motion / day, presence of edema and degree, and mood changes. The weight, state of diarrhea, edema and mood changes were checked in 1st ,3rd ,7th ,10th and 14th day.

4.5. Tool validity and reliability
Validity:
The tool was submitted to a panel of five experts in Pediatrics to confirm its validity. The modifications on the tool were done according to the panel judgment in relation to appropriateness of the content and sequence accuracy of items.
Reliability:
Reliability of the tool was performed to confirm validity of tool and was statistically calculated. The internal consistency was measured to identify the extent to which the items of the tool measure the same concept and correlate with each other. Reliability of the study's tools was done by alpha Cronbach test 0.75.

4.6. Pilot study
The pilot study was done on 10% of sample size. The pilot study was conducted to test the feasibility of the study, and application of tool. Subjects who shared in the pilot were included in the study sample.

4.7. Ethical consideration:
- Approved by ethical committee of Sudanese medical specialized board.
- Permission from hospital administration.
- Consent from participants' parents.
- No interference with the management protocol.

Data were handled with a high degree of confidentiality at all stages in the study, name and mobile number just for follow up.

4.8. Data collection procedure
Data were collected from Children aged 6 months < 5 years who had been admitted to Ahmed Gasim Pediatric Hospital and Mohammed Alamin Hamed Pediatric Hospital with severe acute malnutrition. Data collection period was 6 months started from Jan. 15th – July 15th 2015

Candidates who fulfilled the criteria were randomly divided into two groups. The study group received nutritional management + gum Arabic and the control group received nutritional management only for two

weeks.

Treatment duration was two weeks for each child individually during which he/ she received the gum Arabic

Gum Arabic used was Tayebat or sweetfibre (Blended powdered exudates of stems and branches of Acacia Senegal and Acacia Seyal trees). The dose was determined by pediatric gastroenterologist experienced in Gum Arabic Medical Application (*Prof. Mohieldin Sabir O.*), and it was as follow:

- Infants below one year received 5 gms/ 8 hourly for two weeks.
- Children aged one year and above received 10gms/ 8 hourly for two weeks.

4.9. Statistical analysis

Data were summarized, tabulated, and presented using descriptive statistics in the form of frequency distribution, percentages, means and the standard deviations as a measure of dispersion.

A statistical package for the social science (SPSS), version (20) was used for statistical analysis of the data, as it contains the test of significance that given in standard statistical books. Numerical data were expressed as mean and SD. Qualitative data were expressed as frequency and percentage. Probability (P-value) is the degree of significance, less than 0.05 was considered significant (*).

4.10. Study limitation:

There is scarcity in published studies about usage of Gum Arabic among Malnourished children.

5. Results

Table 1: characteristics of the children participating in this study (6 – 59 months) (n = 162).

Personal data	No.	%
Age/ months		
6 -	42	25.9
13 -	88	54.3
25 -	28	17.3
37 -	3	1.9
49-59	1	0.6
Gender		
Male	104	64.2
Female	58	35.8
Weight for height Z-Score day1		
<-1SD	25	15.5
<-2SD	19	11.7
<-3SD	101	62.3
<-4SD	17	10.5

Table 1 shows the characteristics of the children participating in this study. It was found that: 54.3% of the children their age ranged between 13- 24 months and only 0.6% their age ranged between 49-60 months. Males are 64.2% of children with male: female ratio 1.8: 1. 62.3% of children are below -3 SD and 10.5% are below - 4SD.

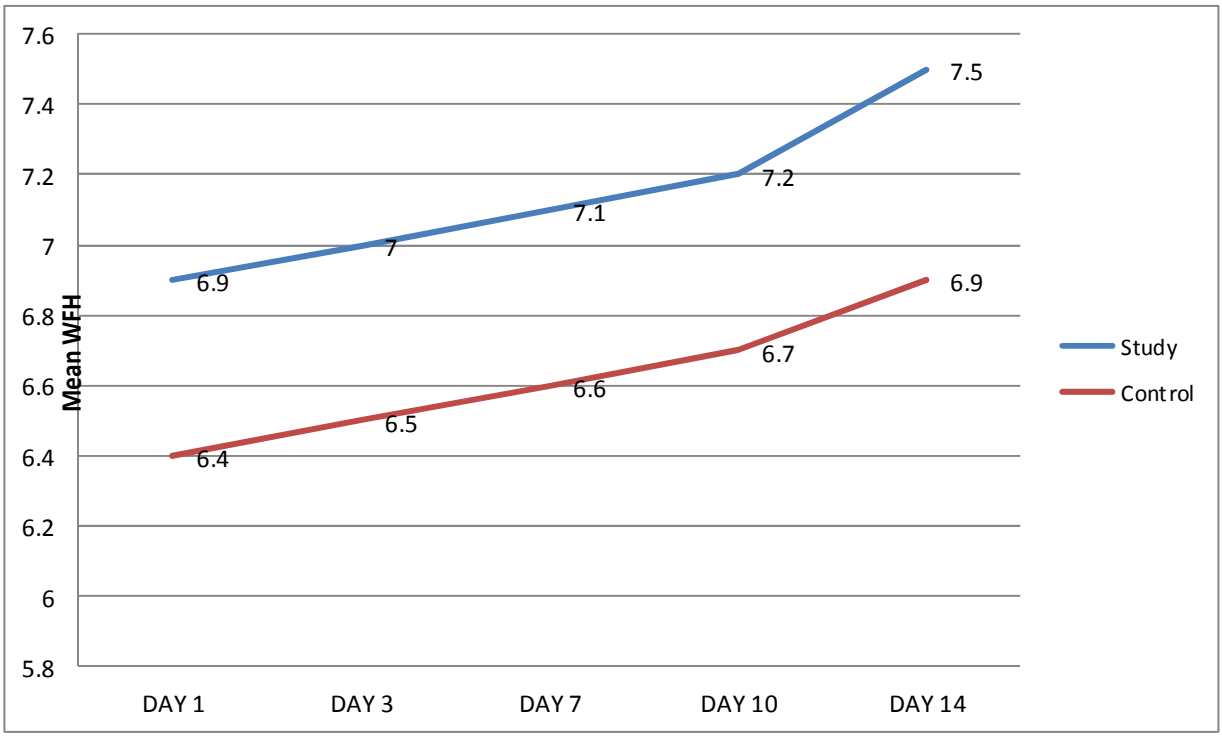

Figure 1: Mean scores of WFH among the study and control groups of malnourished children in 5 reported reading

Figure 1: shows mean scores of weight for height among study and control groups in 5 reported reading. On the 1st day, it was found that, mean scores of weight for height among the study and control groups were 6.9 kg and 6.4 kg respectively, on the 3rd day was 7.0 kg and 6.5kg respectively, on the 7th day was 7.1kg and 6.6 kg respectively, while on the 10th day was 7.2 kg and 6.7 kg respectively, and on the 14th day was 7.5 kg and 6.9 kg respectively.

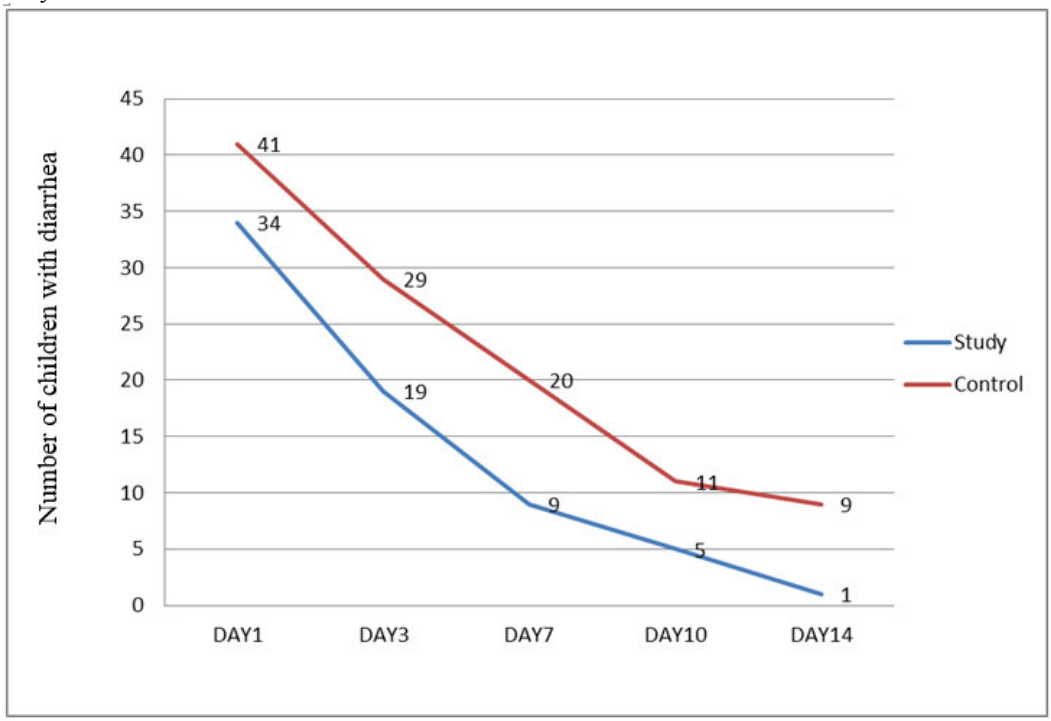

Figure 2: number of children with diarrhea among the study and control groups of malnourished children in 5 reported reading

Figure 2: shows number of children with diarrhea among the study and control groups: on the 1st day was 34 children vs 41 children respectively, on the 3rd day 19 children vs 29 children, on the 7th day 9 children vs

20 children, on the 10th day 5 children vs 11 children, and on the 14th day one child vs 9 children had diarrhea respectively.

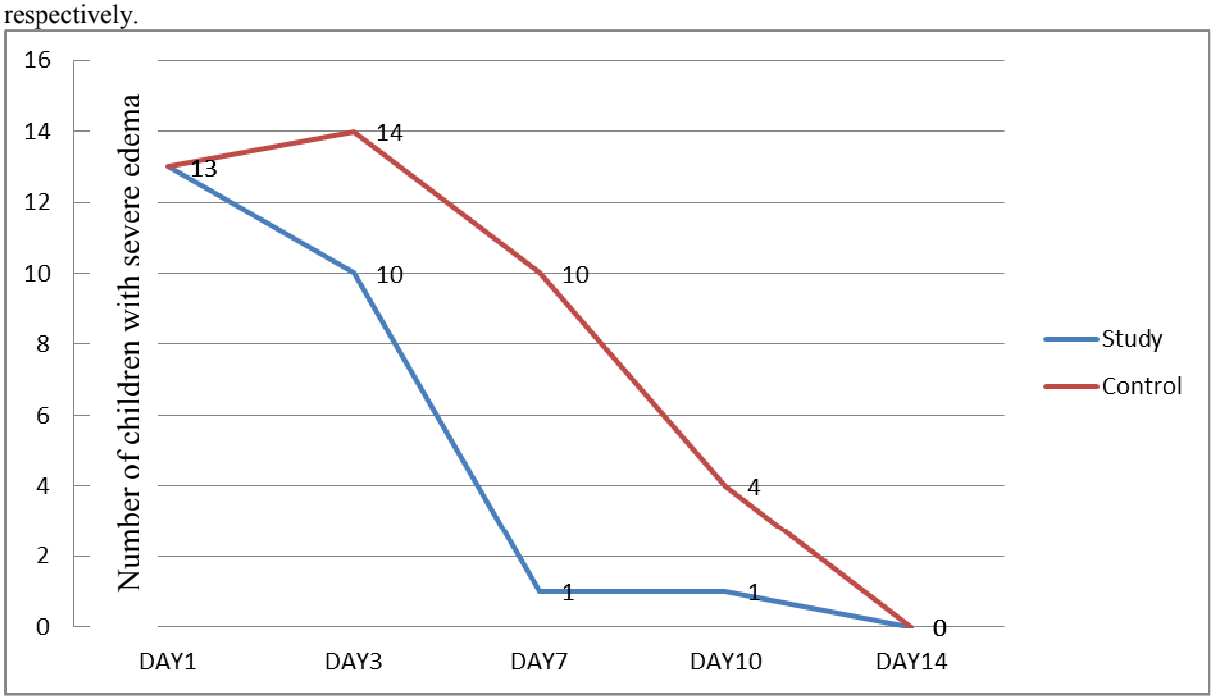

Figure 3: number of children with severe edema among the study and control groups of malnourished children in 5 reported reading

Figure 3: shows a number of children with severe edema among the study and control groups: on the 1st day was 13 children vs 13 children respectively, on the 3rd day 10 children vs 14 children, on the 7th day 1 child vs 10 children, on the 10th day 1 child vs 4 children, and on the 14th day no one child had edema respectively.

Table 2 Relation between the study & control groups as regards to edema in 5 reported reading

Edema	Groups				*p*- value
	Study		Control		
	No.	%	No.	%	
1st day					
Mild	3	10	5	18.5	0.643
Moderate	14	46.7	9	33.3	
Severe	13	43.3	13	48.2	
3rd day					
Mild	6	24	4	14.3	0.801
Moderate	9	36	10	35.7	
Severe	10	40	14	50	
7th day					
Mild	7	46.7	9	36	.05*
Moderate	7	46.7	6	24	
Severe	1	6.6	10	40	
10th day					
Mild	4	80	3	17.7	.007*
Moderate	0	0	10	58.8	
Severe	1	20	4	23.5	
14th day					
Mild	0	0	6	50	.006*
Moderate	1	100	6	50	
Severe	0	0	0	0	

*statistical significant

Table 2 illustrates relation between the study & control groups as regards to edema in 5 reported reading. On the 1st day, it was found that, 43.3% vs 48.2% of children among the study and control groups had severe edema respectively, on the 3rd day was 40% vs 50% respectively with no statistical significant difference. While on the 7th day was 6.6% vs 40% had severe edema respectively, on the 10th day 80% vs 17.7 % of children

had mild edema respectively, and on the 14th day 100% vs 50% of children had moderate edema respectively with statistical significant differences.

Table 3 Relation between the study & control groups as regards to mood changes in 5 reported reading

Mood changes	Groups				*p*- value
	Study		Control		
	No.	%	No.	%	
1st day					
Irritable	48	59.3	58	71.6	0.002*
Apathetic	17	21	22	27.2	
Calm	15	18.5	1	1.2	
Active & smile	1	1.2	0	.0	
3rd day					
Irritable	21	27.6	43	53.1	
Apathetic	7	9.2	19	23.5	0.0001*
Calm	15	19.7	11	13.6	
Active & smile	33	43.5	8	9.8	
7th day					
Irritable	10	13.3	29	36.7	
Apathetic	2	2.7	7	8.8	0.0001*
Calm	5	6.7	13	16.5	
Active & smile	58	77.3	30	38	
10th day					
Irritable	4	5.8	15	20.2	
Apathetic	0	0.0	1	1.4	0.0001*
Calm	2	2.9	19	25.7	
Active & smile	63	91.3	39	52.7	
14th day					
Irritable	1	1.4	9	12.7	
Apathetic	0	0	1	1.4	0.0001*
Calm	0	0	9	12.7	
Active & smile	68	98.6	52	73.2	

*statistical significant

Table 3 illustrates relation between the study & control groups as regards to mood changes in 5 reported reading. On the 1st day it was found that: 59.3% vs 71.9%, on the 3rd day 27.6% vs 53.1%, on the 7th day was 13.3 % vs 36.7%, on the 10th day 5.8% vs 20.2 %, and on the 14th day 1.4% vs 12.7% of children among the study and control groups had irritable with statistical significant difference.

DISCUSSION

Gum Arabic (acacia Senegal) is a complex polysaccharide indigestible to both humans and animals. It has been considered as a safe dietary fiber by the United States, Food and Drug Administration (FDA) since the 1970s[5].

There are many studies on its use in adults' specially in renal disease and its effect on body mass index and body fat, some studies on diarrhea and celiac disease in children, but there is a paucity of data regarding its use in malnourished children.

In this study we aimed to concentrate on its effects on malnourished children and make use of its benefits.

The current study showed predomination of a group aged from 6 months to less than 2 years for malnourished children, males were more with percentage and ratio of 1.8: 1, and these are similar findings of Irena AH who reported that, males were more frequent than females [10]. Weight for height less than -3SD was reported in most participants, others who had weight for height < -2 SD represented, and they were classified as malnourished by presence of edema.

Diarrhea was observed in less than half of patients, and the study was conducted before start of summer season where a higher rate of diarrhea among children is expected. This is less than what is reported by Irena who reviewed that, the majority of the children, 67.3% (261/388) is presented with diarrhea [10].

In Sudan, 750,000 child suffer from Severe Acute Malnutrition every year. Children malnutrition rates in eastern Sudan's Red Sea, Kassala and Gedaref States are the highest in the country, with an estimated 30% of children under the age of five years, moderately or severely malnourished. [11].

Edema is a common presentation for malnutrition, observed by Irena AH and the colleagues in 68.9% (295/428) at admission [10]. In our study it is observed that, there is more than one third of the patients, among whom severe edema was the commonest (26 out of 57).

Distribution of participants in the current study according to their mood showed that, most of them were irritable. During the study period, using of gum Arabic showed significance and early improvement in mood in the study group 98.6% of patient on the 14th day of the study were active and smiling, while 26.8% of babies who did not take gum Arabic still irritable or apathetic (the control group). This improvement was clear from the early days of the study, on the 3rd day: 43.4% from the patients who take gum Arabic were active and smiling (*P*-value 0.001), there was only one on the starting day versus 9.9% from the control group. Day7: 77.3% patients from the study group were active and smiling (*P*-value 0.001), (37.97% from the control group). Day10: 91.3% of our patients take gum Arabic were active and smiling (*P*-value 0.001) while from those not taking gum Arabic 47.3% still irritable or apathetic. (Measuring mood changes depends on a clinical observation I did not find a clear classification for the mood changes in malnutrition). This agrees with the study done by Mohamed and Sabir who reported that most of children with celiac disease who were taking GA have improved regarding irritability [12].

Diarrhea showed a higher rate of decrease with patients who use Gum Arabic with significant (97.1% P-value 0.010) when compared to control group (78.1%) between day-1 and day 14. In day-7 and day-14, the study is significantly with a higher rate of decrease, day7 :73.5% *P*- value 0.032 and day 14: 97.1 *P*-value 0.010. Decrease in diarrhea clearly started in the study group since day 3, and it stopped in 44.1% versus 29.3% in the control group. The Sudanese study in 2012 has revealed that diarrhea stopped within 24 hours in 90%. It was concluded that sweet fiber as an additive to WHO-ORS reduces the duration of diarrhea. It decreases diarrhea complications [13].

Another study conducted by Mohamed and Sabir showed that symptoms of chronic diarrhea in most children with celiac disease who took gum Arabic have improved [12]. Our study confirms that the effect of using Gum Arabic in diarrhea for different reasons, malabsorption, infection or others as all these found in patients with malnutrition.

The group who used gum Arabic showed more increase in weight for height when it is compared to the control group during the study period; (0.6350 kg versus 0.4887 kg respectively) with percentage of 9.26% versus 7.61% respectively. Improve in weight by using Gum Arabic has been revealed previously by Mohamed and Sabir among children with celiac disease. [12]

The study in Wad Madani by Ishag and Mohammed revealed that, Gum Arabic resulted in an increase in weight gain near to that, resulted from using F100; they reported that, weight gain according to the treatment formula showed that group one, kwash milk formula mean weight gain of 820 g, group two F100 formula mean weight gain of 1060.77 g, group three Gum Arabic formula mean weight gain was 1029.38g [14].

The study group showed quicker response in decreasing edema when compared to the control group; by day-7 only one out of 13 had severe edema in the group who used gum Arabic versus 10 out of 13 in the control group, and the variation was revealed statistically significant (*P*-value 0.05). A number of children with edema in the study group (severe, moderate and mild) also significantly decreased between day-1 and day-14 (P value = 0.006); by day-14 there was only one child with moderate edema in the study group out of 30 children, versus 12 out of 28 in the control group so edema subsided in 96.7% of the group who used gum Arabic while 42.9% of babies who did not take gum Arabic still have edema by day 14. This reflects the rapid improvement in nutritional status in patients who use gum Arabic.

CONCLUSION

Using Gum Arabic among malnourished children in addition to the recommended protocol of managing malnutrition showed positive outcome. Diarrhea and edema were significantly decreased among children who used gum Arabic. Other significant improvement was shown by gaining weight and shifting the mood of children from irritability and apathetic to an active and a smiling mood.

RECOMMENDATIONS

- Since Gum Arabic has a good acceptance of usage in Sudanese community, available and cheap, it can be easily applied and added to ReSoMal or to RUTF (ready-to-use-therapeutic food) to make use of its advantages.
- Further studies are required to assess the different positive effects of Gum Arabic on managing malnutrition to monitor the treatment outcomes.
- Further studies with laboratory investigations are recommended to confirm the effect of different nutrient contents of gum Arabic.
- I recommend Production of capsules of Gum Arabic 5, 10 and 15 grams.
- Wide and well-established use of gum Arabic as Prebiotic will increase its economic values.

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